Field Test Program for Long-Term Operation of a COHPAC® System for Removing Mercury

DOE/NETL's
Mercury Control Technology R&D
Program Review
Pittsburgh, PA July 14-15, 2004

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Acknowledgements

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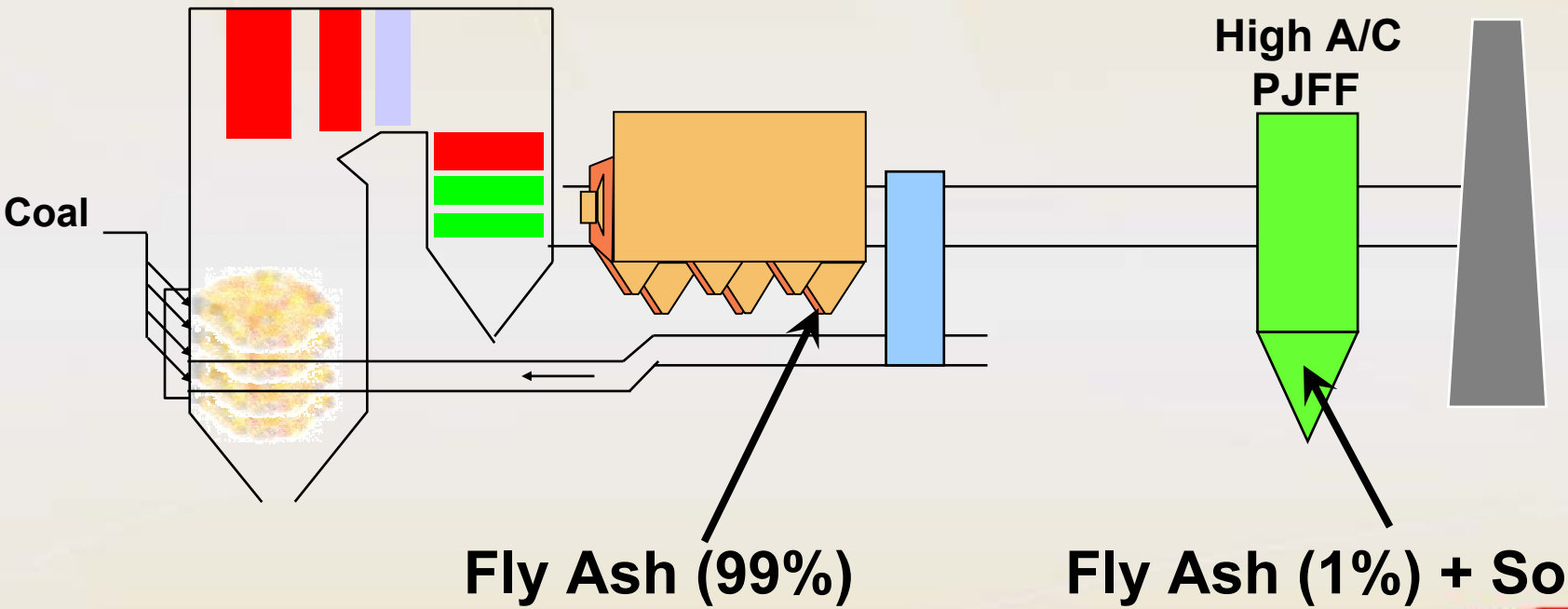
Test Team

- Southern Research Institute
- Reaction Engineering
- Grubb Filtration Testing Services
- Hamon Research-Cottrell
- Weston

COHPAC® Configuration



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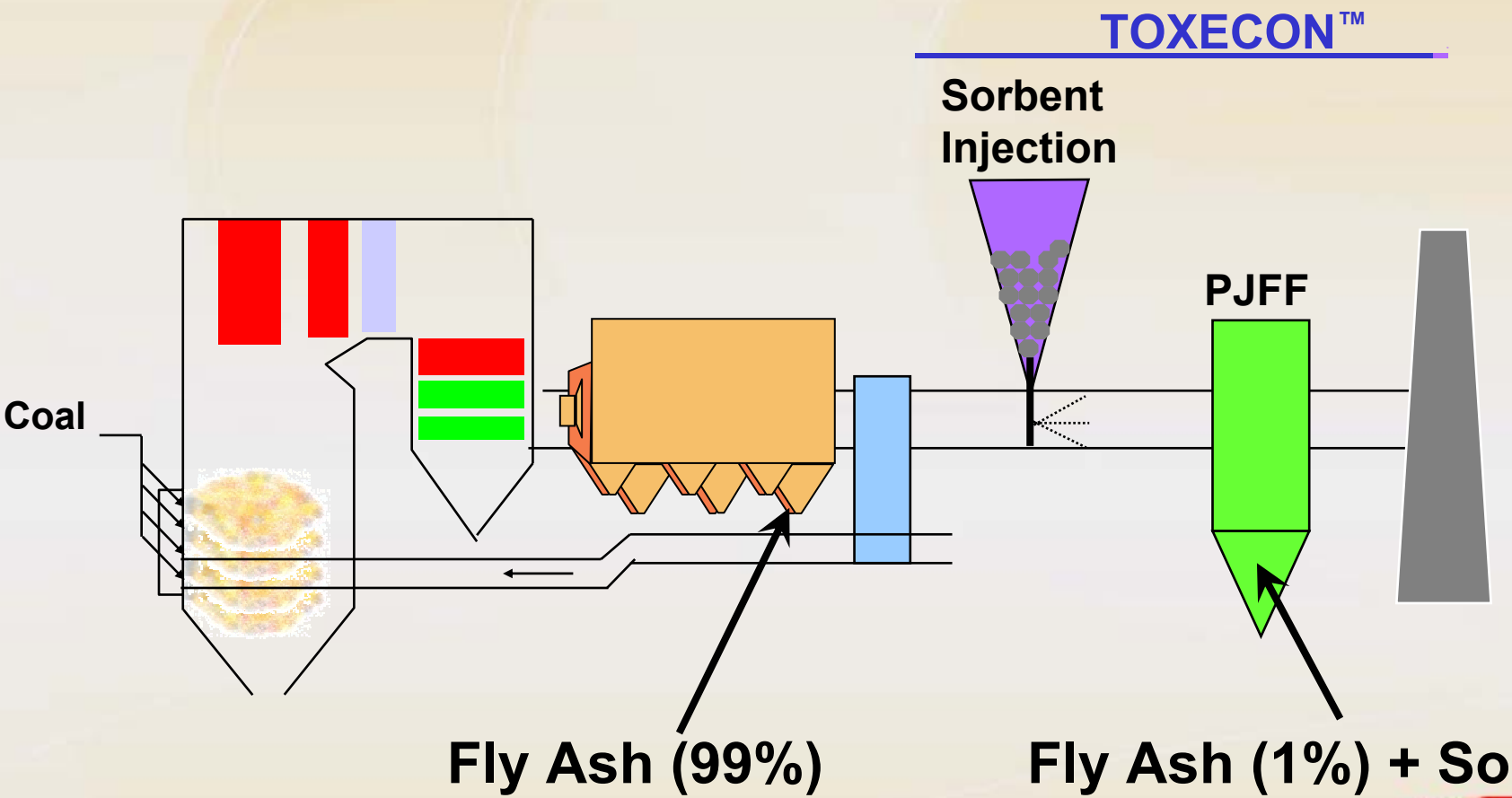
TOXECON™ Configuration



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Alabama Power E. C. Gaston Unit 3

- 270 MW firing a variety of low-sulfur, washed eastern bituminous coals
- Particulate Collection:
  - Hot-side ESP; SCA = 274 ft^2/kacfm
  - COHPAC™ baghouse
- Primary funding from DOE/NETL and EPRI with cofunding provided by:
  - Southern Company
  - Ontario Power Generation
  - TVA
  - Duke Power

- **First Energy**
- **Hamon Research-Cottrell**
- **Arch Coal**
- **Norit Americas**

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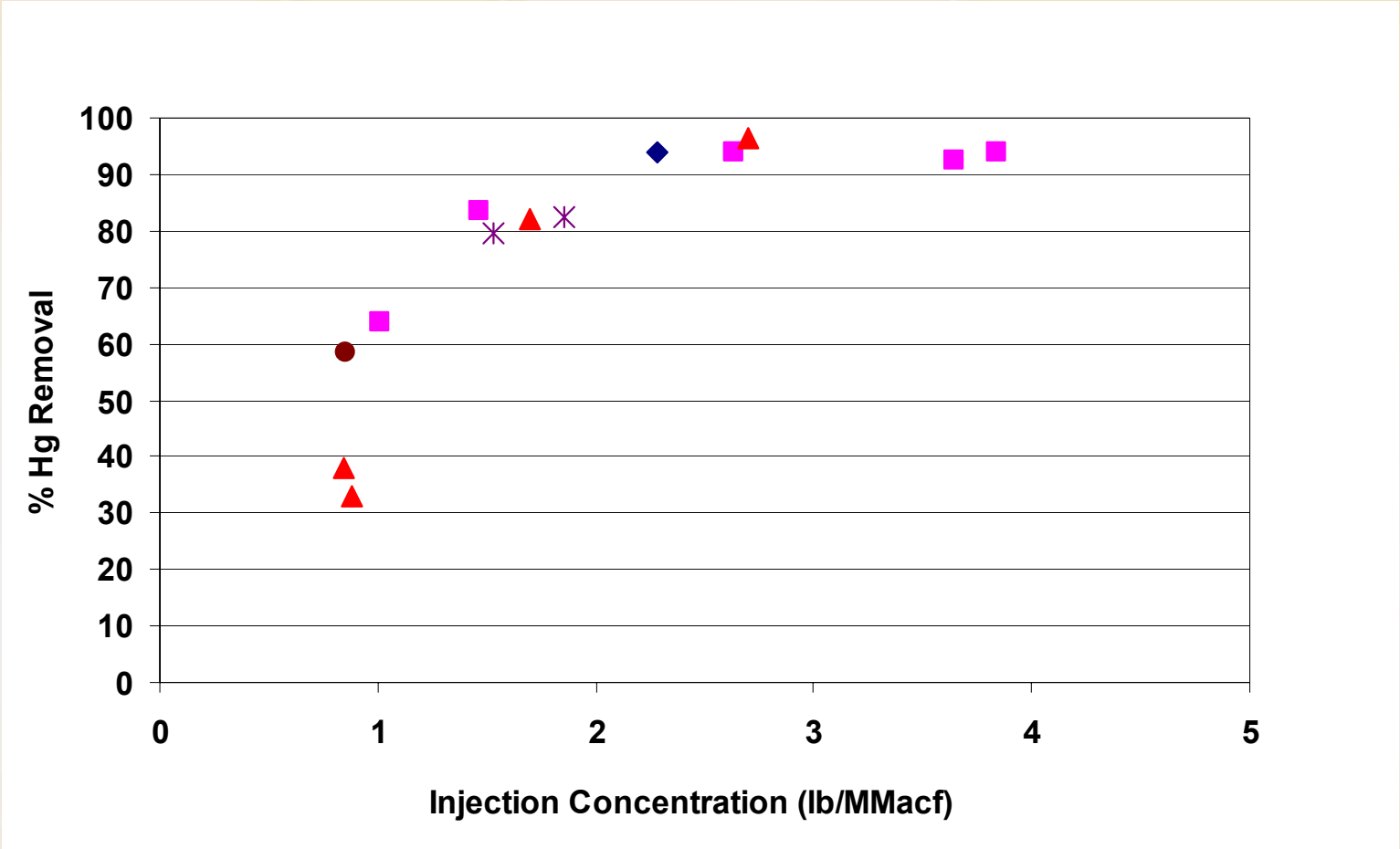
Phase I Test Results With Activated Carbon (2001)



Phase I and II Test History

Phase I Results

- Up to 90% mercury removal was achieved for short-term tests
- COHPAC® cleaning increased proportionally with carbon injection
- Two-week test injection rate limited by cleaning frequency (1.5 p/b/h max)
  - Average ~ 82%
  - Maximum ~ 94%
  - Minimum ~ 70%

Phase II Goals

- Determine maximum mercury removal
  - existing conditions
  - long-term, continuous operation
- Evaluate options to overcome cleaning limitations and achieve higher mercury removal
  - High perm bags
  - Lower air-to-cloth ratio

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TOXECON™ Development Goals

- Determine design criteria and costs for new TOXECON™ systems
- Determine advantages/disadvantages of high-permeability fabrics
- Determine balance-of-plant impacts

Gaston Long-Term Test Plan

- Six month test with original 2.7-denier bags ☑
  - Bags installed 3 years before test started
- Six month test with high-perm bags ☑
  - 7-denier
- Alternative carbon tests ☑

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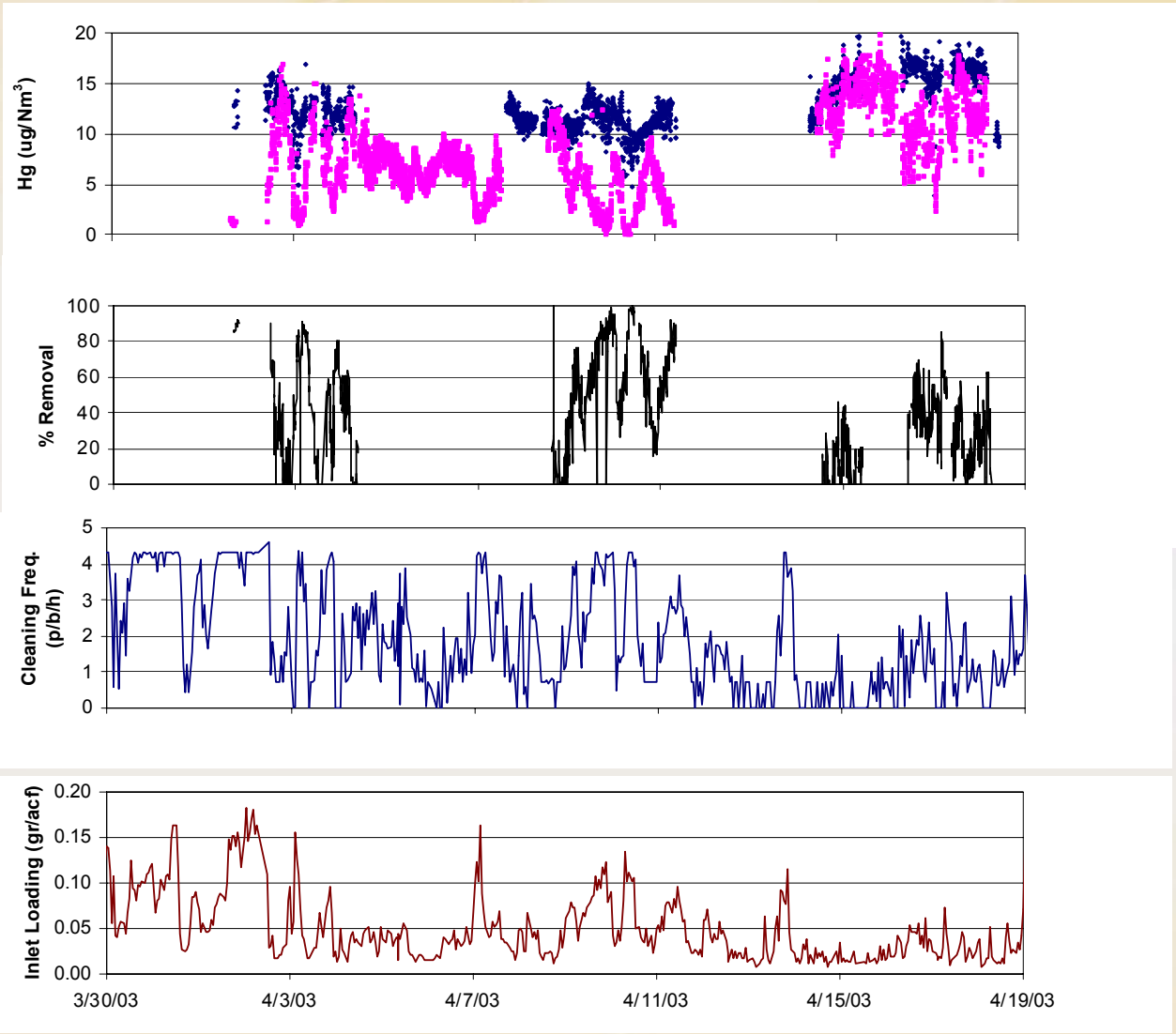
Six-Month Test Periods

- Baseline
- Optimization
- Long-term testing

Hg CEM Measurements Baseline 1



Baseline Performance Comparison: 2001 Versus 2003

	2001	2002
Average LOI	11%	17%
Average Hg Removal	0%	26%
Average Hg Inlet Mass Loading	<0.01 gr/acf	0.06 gr/acf
Average Cleaning Frequency	<0.5 p/b/h	~2 p/b/h

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Optimized Injection Control Logic

Inlet Loading (gr/scf)	Inlet Loading (gr/acf)	Injection Concentration (lbs/MMacf)	Injection Rate (lbs/h)
<0.1	~0.07	0.52 or 0.66	16 or 20
<0.2	~ 0.14	0.35	10
>0.2	~ 0.14	0	0

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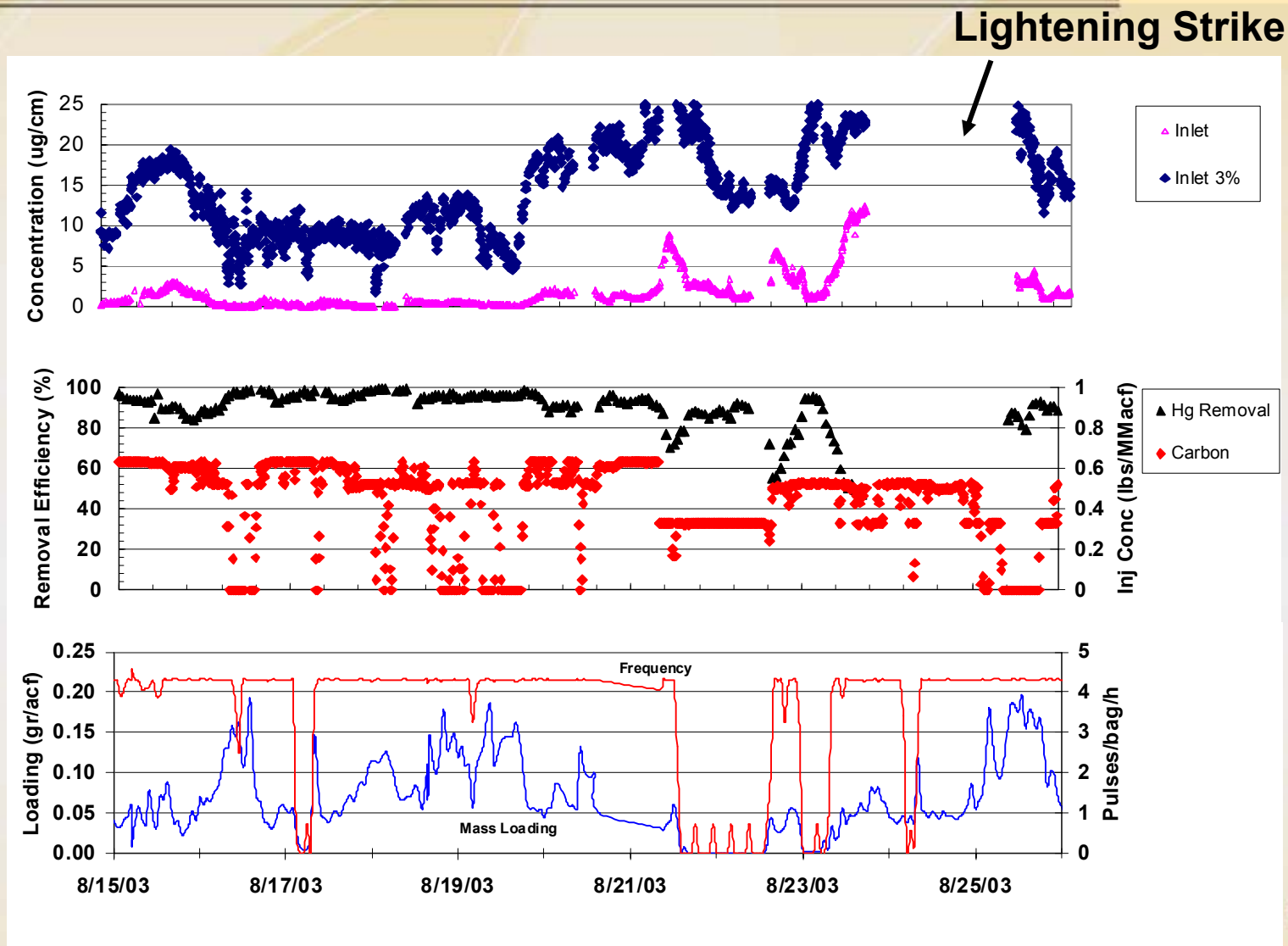
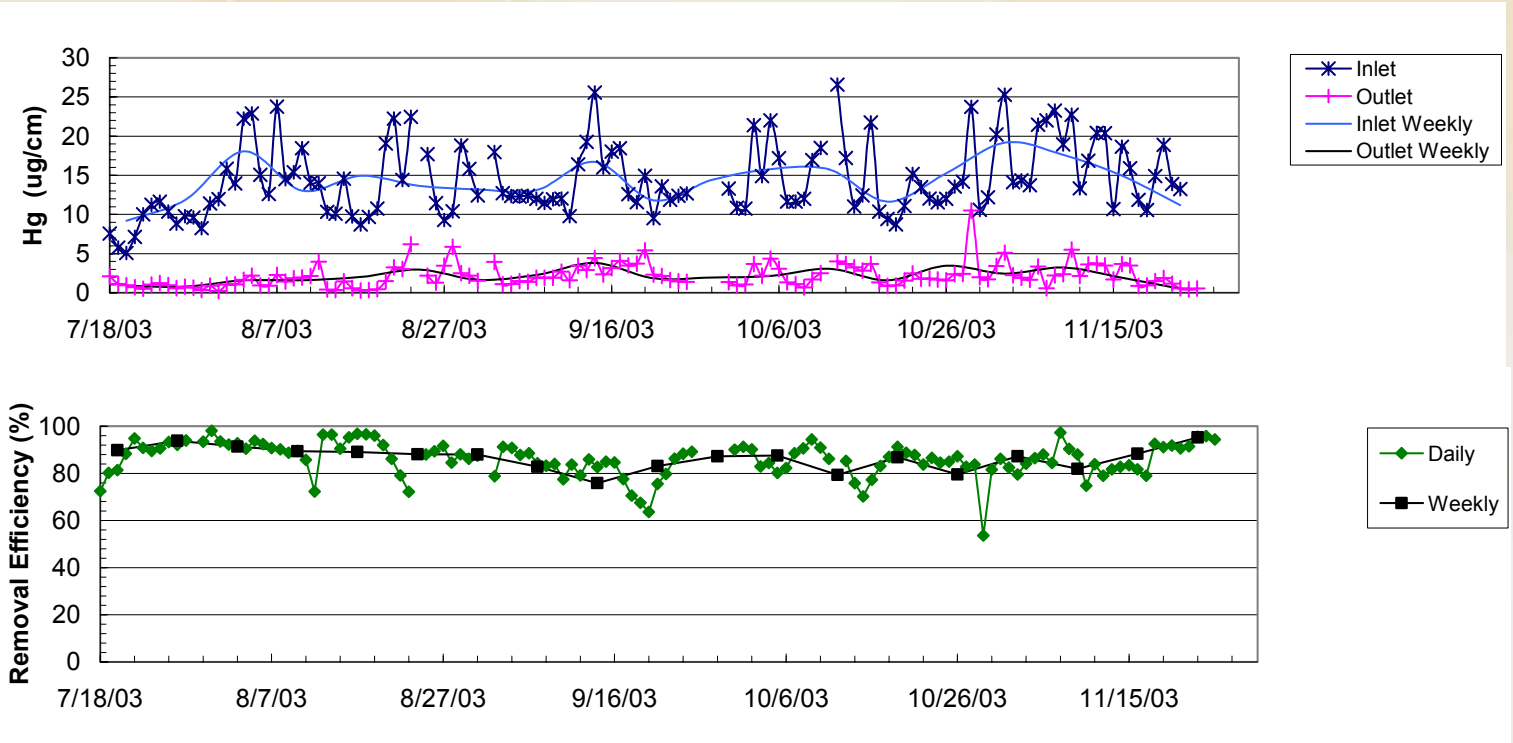
Long Term: August 15 – August 27



Daily and Weekly Average Mercury



Average Inlet and Outlet Mercury

Week Starting	Inlet Mercury ($\mu g/m^3$)	Outlet Mercury ($\mu g/m^3$)	Mercury Removal (%)	Standard Deviation Hg Removal
7/20/03	9.2	0.8	91	6.5
7/27/03	11.8	0.8	93	3.6
8/3/03	18.1	1.6	91	4.5
8/10/03	13.0	1.6	87	10.7
8/17/03	14.9	2.0	86	12.0
8/24/03	13.9	2.9	79	6.3
8/31/03	13.2	1.7	87	5.7
9/7/03	13.1	2.3	82	6.3
9/14/03	16.7	3.8	77	10.6
9/21/03	11.8	1.9	83	7.3
9/28/03	11.3	1.1	90	1.6
10/5/03	15.8	2.16	86	6.3
10/12/03	15.8	3.1	80	8.7
10/19/03	11.6	1.6	86	6.2
10/26/03	15.2	3.5	77	14.6
11/2/03	19.2	2.4	87	6.6
11/9/03	17.6	3.2	82	6.5
11/16/03	14.9	1.9	87	7.1
Overall Average	**14.3**	**2.1**	**85.6%**	

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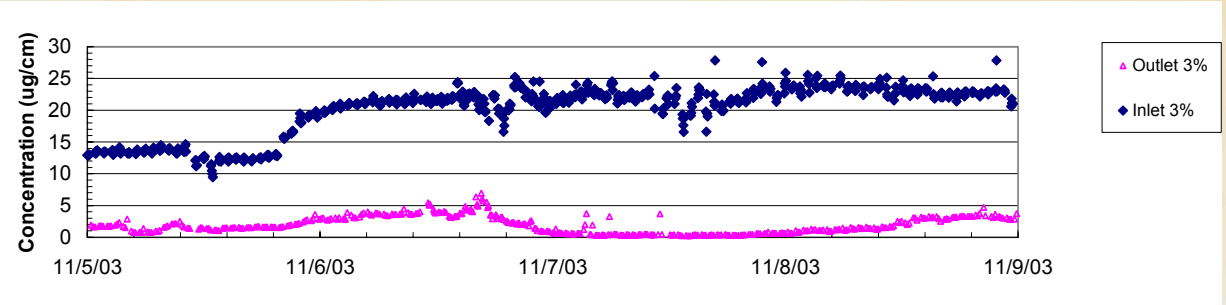
Low Load/Low Flow Test

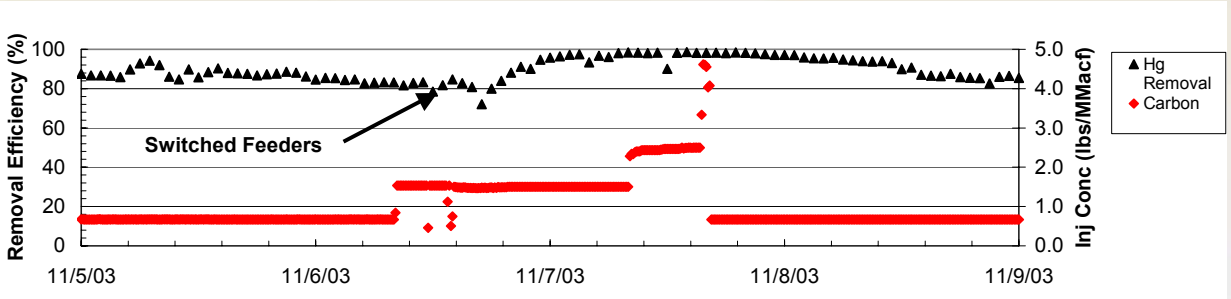
- Baseline conditions limit injection concentration
- Current air-to-cloth ratio of 8.0 ft/min is too high for TOXECON™
- Low load test conducted to simulate operation at air-to-cloth ratio of 6.0 ft/min
  - APC arranged for 72 hours of operation at low, steady load

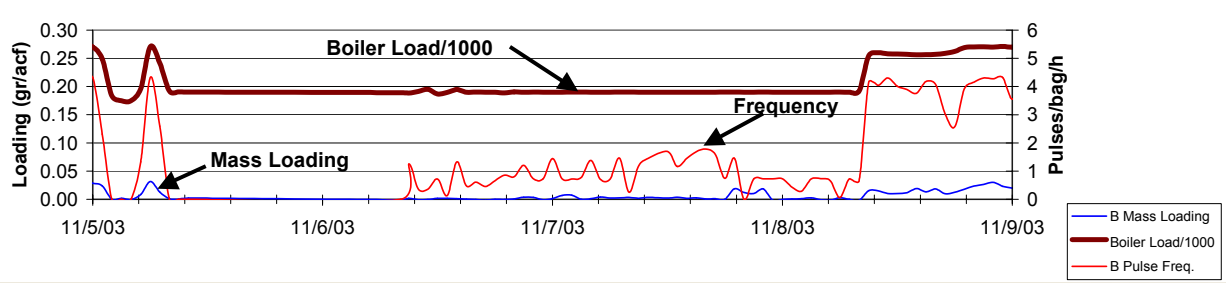
Low Flow Test

Unit 3 Boiler Load	270 MW	195 MW
Flow (acfm)	520,000	375,000
A/C Ratio	~8.0	~6.0

Low Load Test: A/C = 6.0 ft/min







Results from Low Flow Test

Injection Rate (lb/h)	Injection Concentration (lbs/MMacf)	Inlet Hg Concentration (µg/Nm3)	Outlet Hg Concentration (µg/Nm3)	RE (%)	Cleaning Frequency (pulses/bag/hour)
20	0.9	20.6	3.2	84.2	0.6
45	2.0	22.2	1.0	94.6	0.8
70	3.3	21.4	0.61	97.1	1.4

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High-Perm Bag Tests

- High-Perm Bags
  - EPRI Development
  - 7.0 vs. 2.7 denier
  - 30 vs. 130 cfm/ft^2 @0.5”H_2O
- Demonstrate improved cleaning performance
- Increase carbon injection to achieve higher average removal
- Target maximum cleaning frequency of 1.5 p/b/g

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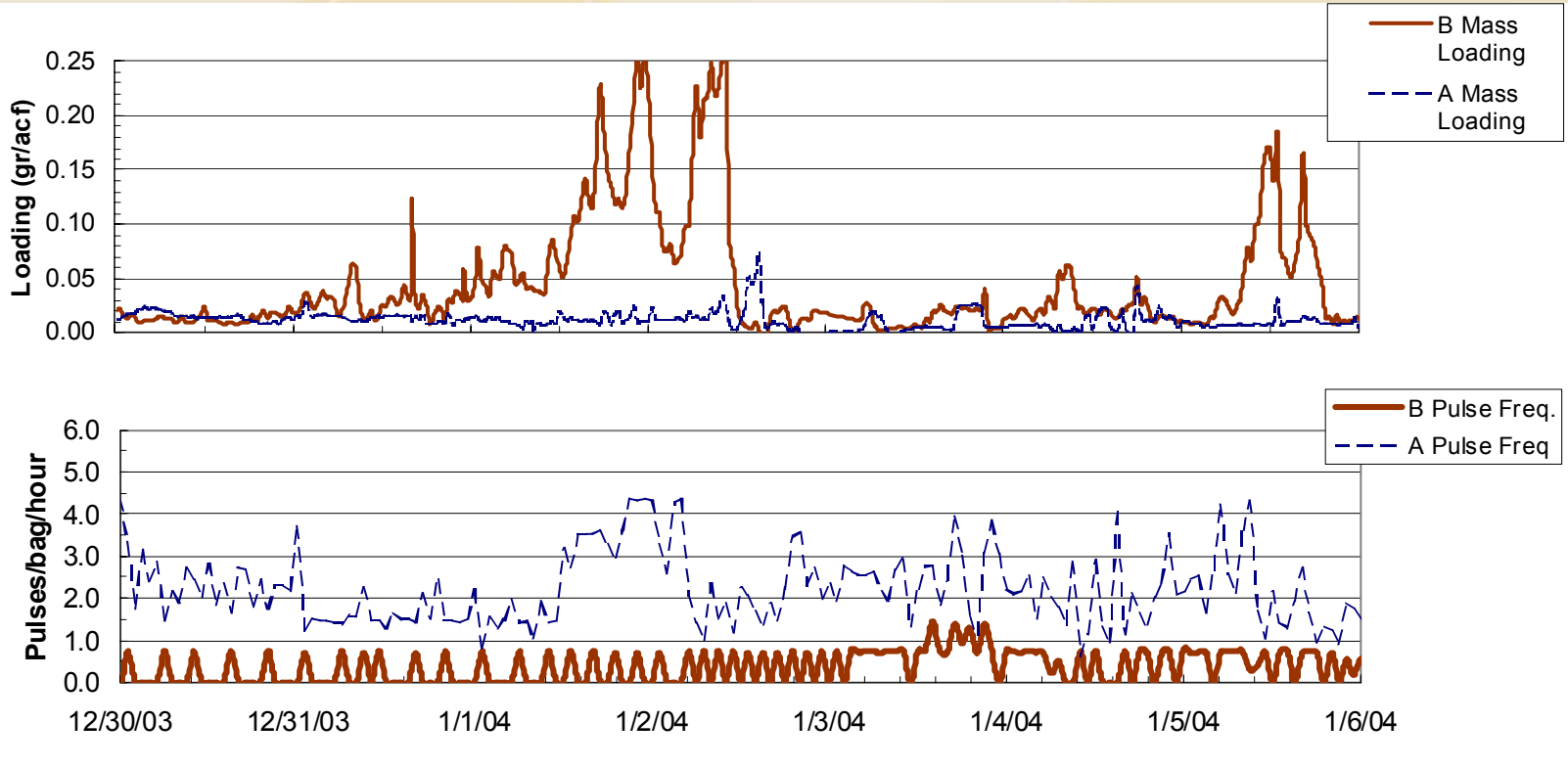
Baseline:High-Perm Bags

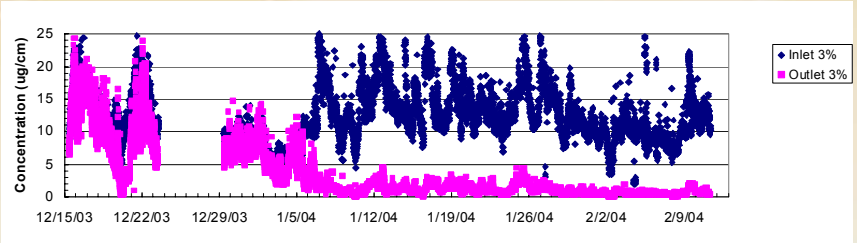


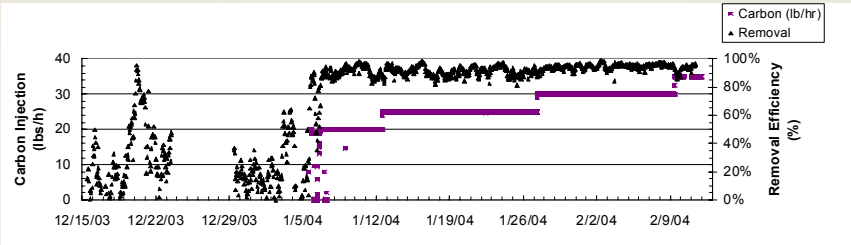
Optimization:High-Perm Bags

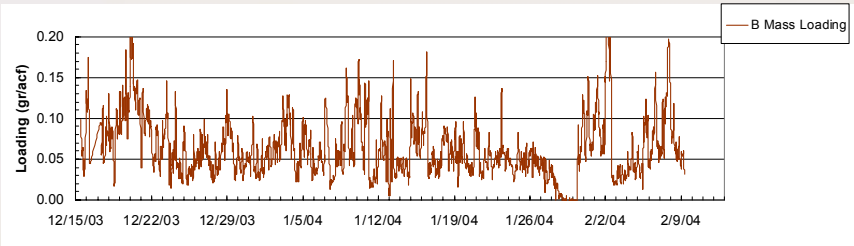
Injection Rate (lb/h)	Injection Concentration (lbs/MMacf)	RE (%)	Inlet Mass Loading (gr/acf)	Cleaning Frequency (pulses/bag/hour)
20	0.6	87	0.1	0.6
25	0.8	91	0.05	0.7
30	1.0	94	0.06	0.7
35	1.1	93	0.02	0.6
45[a]	1.3[a]	92[a]	0.05[a]	1.0[a]

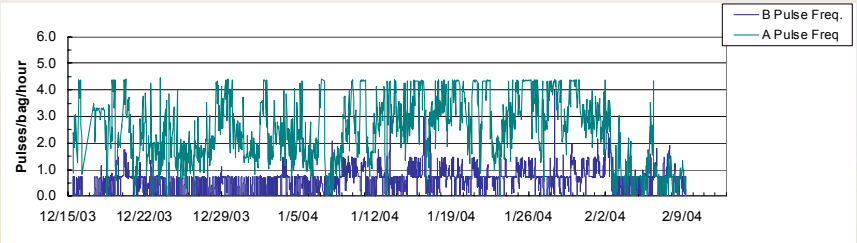
a. Long-term test – these data are from only the first two weeks at this condition.

ACI Performance with High-Perm Bags









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Alternative Carbon Tests

- Goal – broaden the options of suppliers and sorbents evaluated in this program
- Nine different sorbent suppliers invited
- Eight different sorbents tested
- Testing completed last week

Conclusions

- TOXECON units designed at lower A/C ratios are capable of high, 90%, mercury removal
  - Recommending gross A/C = 6 ft/min
- Activated carbon systems are simple and reliable
- Activated carbon effectively reduced mercury for a four month period with a wide range of operating conditions
  - At 0.55 lbs/MMacf, average removal was 86%
  - High baseline removal probably contributed to higher removal at lower than predicted injection concentrations

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Conclusions (Cont.)

- Replacing original 2.7 with 7.0 denier bags improved COHPAC® performance
- Inlet mercury concentration varied by a factor of five, from 6 to 30 $\mu g/Nm^3$
- Testing on high-perm bags at higher carbon injection concentration achieved 90% average mercury control, but removal was still variable
- Maximum carbon injection rate was limited by cleaning frequency on all tests